TM no. M-53-77-1

TECHNICAL MEMORANDUM

title: RUNWAY FRICTION MEASUREMENT AND PAVEMENT CONDITION SURVEY, USNOLF SAN NICOLAS ISLAND, CA~~LIFORNIA~~ by

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CIVIL ENGINEERING LABORATORY
NAVAL CONSTRUCTION BATTALION CENTER
Port Hueneme, California 93043

CONTENTS

INTRODUCTION

In October 1969, the Naval Facilities Engineering Command authorized a series of periodic pavement condition surveys to be conducted at Naval and Marine Corps air stations. The purpose of this condition survey task is to quantitatively survey pavement defects, conduct runway friction measurements, supply information to the station for generation of repair projects, and establish a uniform basis for maintenance and repair efforts. A condition survey was made at the Naval Outlying Field, San Nicolas Island, California by NCEL* in June 1971 (Reference 1).

A new survey of pavement condition and of runway friction measurements was completed by CEL in June 1976. For this new survey, only the runway and parallel taxiway were evaluated. The survey consisted of a sophisticated, statistically-based procedure of pavement defect measurement which permitted the establishment of condition numbers (weighted defect densities) that are direct indicators of the condition of airfield pavement facilities. Runway friction measurements were made using a Mu-Meter, a small friction-measuring trailer. Additional survey efforts included photographic coverage of pavement defect types, preparation of a construction history of the airfield, compilation of current aircraft traffic data, and delineation of requirements for further pavement evaluation efforts at the station.

SCOPE AND UTILIZATION

This report discloses the quantities of defects observed and assigns numbers (severity weights) to these defect measurements that reflect the importance of the defects to operational safety and anticipated maintenance effort. These numbers can be used by station forces for input to determine priorities and scheduling of maintenance and repair efforts; the higher the total weighted defect density, the more severe the pavement defects. Other inputs to the decision-making process - - operational requirements, funding levels, and specific repair procedures - - are beyond the scope of this study.

BACKGROUND

The U. S. Naval Outlying Field, San Nicolas Island, is located approximately 70 miles south of Point Mugu, California, at an elevation of 504 feet. The airfield has one runway and one major taxiway. Runway 12-30 is 10,000 feet long and lies in a generally northwest-southeast direction. The mission of the station is to provide logistic support for the activities of the Pacific Missile Test Center.

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* On 1 January, 1974, redesignated the Civil Engineering Laboratory (CEL) of the Naval Construction Battalion Center, Port Hueneme, California.

CONSTRUCTION HISTORY

Runway 12-30 and Taxiway 12-30 were originally constructed of asphalt stabilized sandstone in 1942-43. Portions of Parking Apron 1 were constructed at the same time. Both the runway and taxiway were lengthened in 1951 and in 1961 a bituminous surface and portland cement concrete ends were added. A complete history of construction for the air station is presented in Appendix A.

CURRENT AIRCRAFT TRAFFIC

A tabulation of the number of aircraft operations for a 12 month period is shown in Table 1. Table 2 lists the aircraft normally based at the station and transient aircraft observed using the station.

PAVEMENT CONDITION SURVEY

Condition Survey Procedure

The condition procedure used at NOLF San Nicolas Island was developed by CEL in 1968. This procedure permits the establishment of condition numbers (weighted defect densities) which are direct indicators of the pavement surface condition. A complete description of the pavement condition survey procedure is presented in Appendix B. It should be noted that Appendix B describes procedures for both asphaltic concrete (AC) and portland cement concrete (PCC) pavements, and includes other pavement facilities in addition to runways. Discrete areas were selected after a preliminary inspection of the pavements. The locations of the discrete areas are shown in Figure 1. Defect severity weights as used at NOLF San Nicolas Island are given in Table 3.

Results of Condition Survey

The results of the survey of each discrete area are shown in the Discrete Area Defect Summary sheets, pages 23 and 24 of this report. Each Discrete Area Defect Summary includes a narrative description of the pavement defects encountered. In addition, photographs of typical pavement conditions noted during the survey can be seen in Figures 2 and 3. Facility Defect Summaries are shown on pages 41 through 42 .

Total weighted defect densities for asphaltic concrete pavements were 0.24A for discrete area R12-1 and 0.85A for discrete area T12-1. For portland cement concrete areas, total weighted defect densities were 0.00C (no visible defects) for discrete area R12-12 to 0.17C for discrete area T12-2.

RUNWAY FRICTION MEASUREMENTS

The skid resistance/hydroplaning characteristics of the runway surfaces were evaluated with a Mu-Meter friction measuring device. The test program consisted of field measurements of skid resistance/hydroplaning potential under standardized, artificially-wet conditions. In addition, both transverse and longitudinal pavement slopes were measured at intervals along each runway centerline to evaluate surface drainage characteristics.

Test Locations

Test sections on the runway were selected to provide a representative sample of the skid resistance properties of the runway. The test section layout is shown in Figure 4. The test sections were selected to provide pavement friction data in: (a) the aircraft touchdown areas, and (b) the runway interior where maximum braking is normally developed.

Test Equipment

The principal items of test equipment used were the Mu-Meter, a tank truck for water application, and a device for measuring pavement slopes.

The Mu-Meter is a small trailer, designed and manufactured by M. L. Aviation of Maidenhead, England. It measures the side-force friction coefficient generated between the pavement surface and the pneumatic tires on the two wheels which are set at a fixed tow-out (yaw angle) to the line of drag. The Mu-Meter is a continuous recording device that graphically records the coefficient of friction, mu*, versus the distance traveled along the pavement.

The water truck provided by the station was a water tanker with a spray bar and pumping system calibrated to place 0.1-inch of water on the skid test strip with each pass.

The slope measuring device consisted of a rectangular aluminum section (10 feet long, 1 inch thick, and 4 inches high) with machinists' levels attached to define slope from 0 to 2.5 percent.

Test Procedures

The field test procedures utilized at NOLF San Nicolas Island are those outlined in NAVFAC INSTRUCTION 11132.14B. The methods were:

(1) A preliminary reconnaissance of the pavement surfaces was made and representative test areas (each 1000 feet long) were selected for skid testing.

(2) Transverse and longitudinal slope measurements were made at 1000-foot intervals along the runway centerline. Transverse measurements were made at two places on each side of the centerline covering a distance of approximately 20 feet. Longitudinal measurements were made on the centerline at the same stations where the transverse measurements were made.

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* The symbol mu or μ designates the coefficient of friction which is a constant used to represent the ratio of frictional force to force normal to the pavement surface.

(3) The water truck, which had been calibrated to apply 0.1-inch of water each time it passed over a test strip, made two passes over the test strip.

(4) Mu-Meter runs at 40 miles per hour, 1.2 times the theoretical hydroplaning speed for this vehicle, were initiated immediately after completion of the second water truck pass. Mu-Meter runs were made in alternate directions at convenient time intervals until a dry pavement condition was reached or 30 minutes had elapsed.

(5) All water truck and Mu-Meter operations were measured to the nearest second using a stop watch.

Runway Friction Test Results

The pavement skid resistance results are reported in terms of mu, coefficient of friction, as measured by the Mu-Meter. The actual friction coefficient versus distance traces as recorded by the Mu-Meter during the first run after wetting for each test section are shown in Figures 5 and 6. The traces show the variation of friction coefficient within each test section. Appendix C contains all test results for each Mu-Meter test section.

Figures 7 and 8 show changes in surface friction coefficient versus time after wetting for each pavement section tested. (Note that the time intervals after wetting at which skid tests were made often differed from one test to another, due to small variations in water truck speed and Mu-Meter adjustments.) These graphs demonstrate the natural drainage characteristics of the runway surface and the time required to return to an essentially dry condition or a consistently high friction coefficient.

A summary of test data and an associated Mu-Meter aircraft pavement rating guide are presented in Tables 4 and 5. The rating guide was developed from the results of an Air Force Weapons Laboratory research program and a joint NASA/AF/FAA test program using actual aircraft correlated with Mu-Meter skid coefficient results. While the current state-of-the-art does not allow a more precise delineation of exact aircraft responses, the rating guide provides a good rule-of-thumb for interpretation of test data.

Table 4 presents the average skid resistance values for each skid test section. From the curves presented in Figures 7 and 8 values of mu were determined for time periods of 3, 15, and 30 minutes after water was applied. The coefficient determined at 3 minutes after water application corresponds to a wet runway condition, and the coefficient determined at 15 minutes after water application corresponds to a damp runway condition. At 30 minutes after wetting, the friction coefficient can be considered a dry pavement condition. The curves in Figures 7 and 8 were extrapolated, if necessary, to obtain friction coefficients at those time intervals. These data indicate the rate at which the pavement skid resistance properties were recovered after the test sections were wetted. By comparing the actual values of mu shown in Table 4 with the expected aircraft response in the associated rating guide, Table 5, it is possible to evaluate aircraft hydroplaning potential.

Measured pavement slopes are shown in Figure 9. Positive transverse slopes indicate water drains to the runway edge without crossing the centerline, while negative transverse slopes indicate drainage crosses the runway centerline before draining to the edge. Positive longitudinal slopes indicate rising pavement grades in the direction of increasing runway stations while negative longitudinal slopes indicate falling grades in the direction of increasing stations.

DISCUSSION OF RESULTS

Condition Survey Results

Quantitative defect density changes for each defect type since the condition survey in 1971 (Reference 1) are summarized in Table 6. Locations of discrete areas are shown in Figure 1 and the numbering of discrete areas is described in Appendix B. Each discrete area and possible causes of changes in defect quantities are discussed in the following paragraphs.

Runway 12-30

R12-1: The slight increase in the amount of longitudinal construction joint cracking is attributed to aging of the pavement surface. The increased amount of patching was the result of utility trench construction.

R-12-2: The spall repairs and joint resealing completed in 1975 eliminated the defects noted in 1971.

Taxiway 12-30

T12-1: Essentially the same comments as discrete area R12-1.

T12-2: Same as discrete area R12-2.

Runway Friction Test Results

The three-minute mu values given in Table 4 show that Test Sections 2 and 3 in the runway interior demonstrated high or some potential for aircraft to hydroplane when the runway is wet. The primary reasons for low friction values in the sections is a lack of surface texture and ponding water. Texture measurements made using procedures developed by NASA and described in Reference 2 gave surface texture depths of 0.009 to 0.013 inches. A surface texture depth of 0.050 inches or greater is recommended in Reference 2. Ponded water was found in Test Section 3 and is attributed to a transverse slope of 0.2 percent and water being retained by ridges of slurry seal where overlaps were made at longitudinal joints. The effect of the ponded water can be seen in Figure 6 showing Run 1 in Test Section 3. The friction coefficient is above 0.60 until the ponded water is encountered and then drops to 0.10 to 0.20.

Test Sections 1 and 4 gave satisfactory friction coefficients.

RECOMMENDATIONS

It is recommended that consideration be given to correcting the lack of pavement surface texture and ponding water. Suggested corrective measures include a porous friction surface or a slurry seal specifically designed to provide adequate surface texture. Depressed areas which cause ponding of water should be surveyed and brought up to the proper grade with a leveling course of asphaltic concrete. A slurry seal would have the additional benefit of sealing the cracks noted in the runway.

COMMENTS ON AIRFIELD DRAINAGE

Suspected subsurface erosion which might influence the structural capacity of Runway 12-30 at NOLF San Nicolas Island was investigated in 1971 and 1972 and reported in References 3 and 4. Both of these investigations recommended remedial measures to correct erosion occurring at that time. Of particular importance is the recommendation to prevent surface water from entering the soil in the area bounded by Runway 12-30, Taxiway 12-30, Taxiway A and Taxiway B. This work has not been accomplished and internal drainage symptoms noted in References 3 and 4 which could lead to pavement damage if subsurface drain piping developed are still present in this area (see Figure 3). It is suggested that the recommendations in References 3 and 4 be implemented and that the runway and taxiway areas be inspected after each rainfall for signs of increased subsurface erosion.

RECOMMENDATION FOR FURTHER EVALUATION EFFORTS

A complete evaluation of all pavements at NOLF San Nicolas Island was made by CEL in 1967 (Reference 5). Since that time, no repairs or construction that would substantially alter the pavement load ratings reported in Reference 5 have been performed. Therefore, no further load-type evaluation is recommended at this time.

REFERENCES

1. Naval Civil Engineering Laboratory, Technical Note N-1208, "Airfield Pavement Condition Survey, USNOLF San Nicolas Island, California", by H. Tomita and R. B. Brownie.

2. Federal Aviation Administration Advisory Circular AC No. 150/5320-12, "Methods for the Design, Construction, and Maintenance of Skid Resistance Airport Pavement Surfaces." Washington, D. C., June 1975.

3. Pavement Analysts Corporation. "Investigation of San Nicolas Island Runway", report submitted to the Commander, Western Division, Naval Facilities Engineering Command, San Bruno, California, June 1971.

4. Naval Civil Engineering Laboratory. Unpublished Technical Note, "Investigation of Runway Subsurface Erosion, NOLF San Nicolas Island", by J. B. Forrest, R. B. Brownie, and M. C. Chapman. Port Hueneme, California, December 1972.

5. Naval Civil Engineering Laboratory, Technical Note N-956, "Airfield Pavement Evaluation, USNOLF San Nicolas Island, California", by D. J. Lambiotte and R. B. Brownie, Port Hueneme, California, April 1968.

Table 1. Aircraft Operations Data for USNOLF San Nicolas Island, California

Reporting Period: 1 January to 31 December 1975

	Military		Civil		Total
	Navy/ Marine Corps	Other Military	Air Carrier	General Aviation	
Number of Operations	2,558	80	1,030	2,859	6,257
Average Monthly Operations for above one-year period:					544

Table 2. Aircraft using USNOLF San Nicolas Island, California

Types of Aircraft:	C-1, C-2, C-9, C-117, C-118, C-130, P-3, S-3, F-4, F-8, F-14, F-86, T-2, T-33, H-1. H-2, H-3, H-46, U-3, C-402, E-2, DC-6

NOTE: Information supplied by NOLF San Nicolas Island, California

Table 3. Defect Severity Weights

Airfield: USNOLF San Nicolas Island, California

Asphaltic Concrete		Portland Cement Concrete	
Defect	Weight	Defect	Weight
Depression	9.0	Depression	9.0
Rutting	9.0	Shattered Slab	9.0
Broken-up Area	9.0	Faulting	8.5
Faulting	8.5	Spalling	7.5
Raveling	7.0	Scaling	7.0
Erosion-Jet Blast	7.5	"D-Line" Cracking	6.5
		Pumping	4.0
Longitudinal, Transverse, or Longitudinal Construction Joint Crack	3.0	Poor Joint Seal	3.0
Pattern Cracking	3.0	Corner Break	3.0
Patching	3.5	Intersecting Crack	3.0
Reflection Crack	1.5	Longitudinal or Transverse Crack	3.0
Oil Spillage	1.5		

Table 4. Summary of Runway Friction Measurements, USNOLF San Nicolas Island, California

Test Location	Average Friction Coefficients		
	3 min. (Mu)	15 min. (Mu)	30 min. (Mu)
Runway 12-30			
Test Section 1	0.62	>0.85	>0.85
Test Section 2	0.46	0.82	0.85
Test Section 3	0.37	0.72	0.85
Test Section 4	0.60	>0.85	>0.85

TABLE 5. MU-METER AIRCRAFT PAVEMENT RATING*

3 Minute Friction Coefficient	Hydroplaning Potential
Greater than 0.50	No hydroplaning problems are expected
0.40 to 0.50	Hydroplaning potential for some aircraft
Less than 0.40	High hydroplaning potential

* Source: Air Force Civil Engineering Center, AF CEC-TR-75-3, Analysis of the Standard USAF Runway Skid Resistance Tests, by John H. Williams, May 1975.

Table 6. Changes in Defect Densities, USNOLF San Nicolas, Island, California

Facility and Discrete Area	Defect Type	Defect Density and Survey Site	
		June 1971	Feb 1976
Runway 12-30			
A12-1 (AC)	TC, LC, LCJ	0.002	0.044
	Patching	0.019	0.030
R-12-2 (PCC)	Spalling	0.152	0.00
	Joint Seal	1.000	0.00
Taxiway 12-30			
T12-1 (AC)	TC, LC, LCJ	0.171	0.192
	Patching	0.000	0.007
	Pattern Cracking	0.000	0.084
T12-2 (PCC)	Spalling	0.104	0.002
	Joint Seal	1.000	0.000

NOTE: A defect density of 0.00 means no visible defects

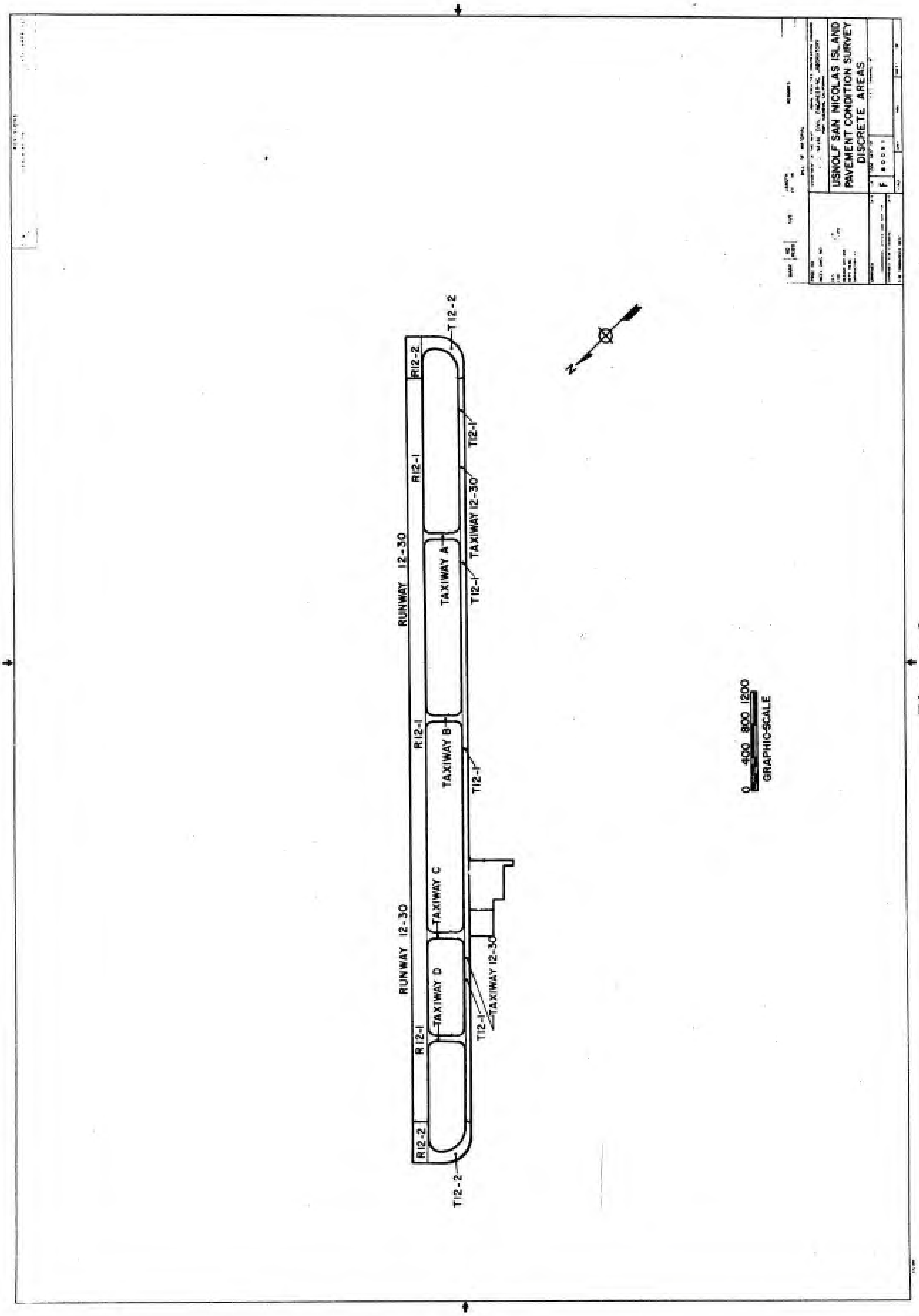

USNOLF SAN NICOLAS ISLAND
PAVEMENT CONDITION SURVEY
DISCRETE AREAS
RUNWAY 12-30
RUNWAY 12-30
R12-1
R12-1
R12-1
R12-2
R12-2
T12-1
T12-1
T12-1
T12-1
T12-2
T12-2
TAXIWAY A
TAXIWAY B
TAXIWAY C
TAXIWAY D
TAXIWAY 12-30
TAXIWAY 12-30
N
0 400 800 1200
GRAPHIC-SCALE

Figure 1

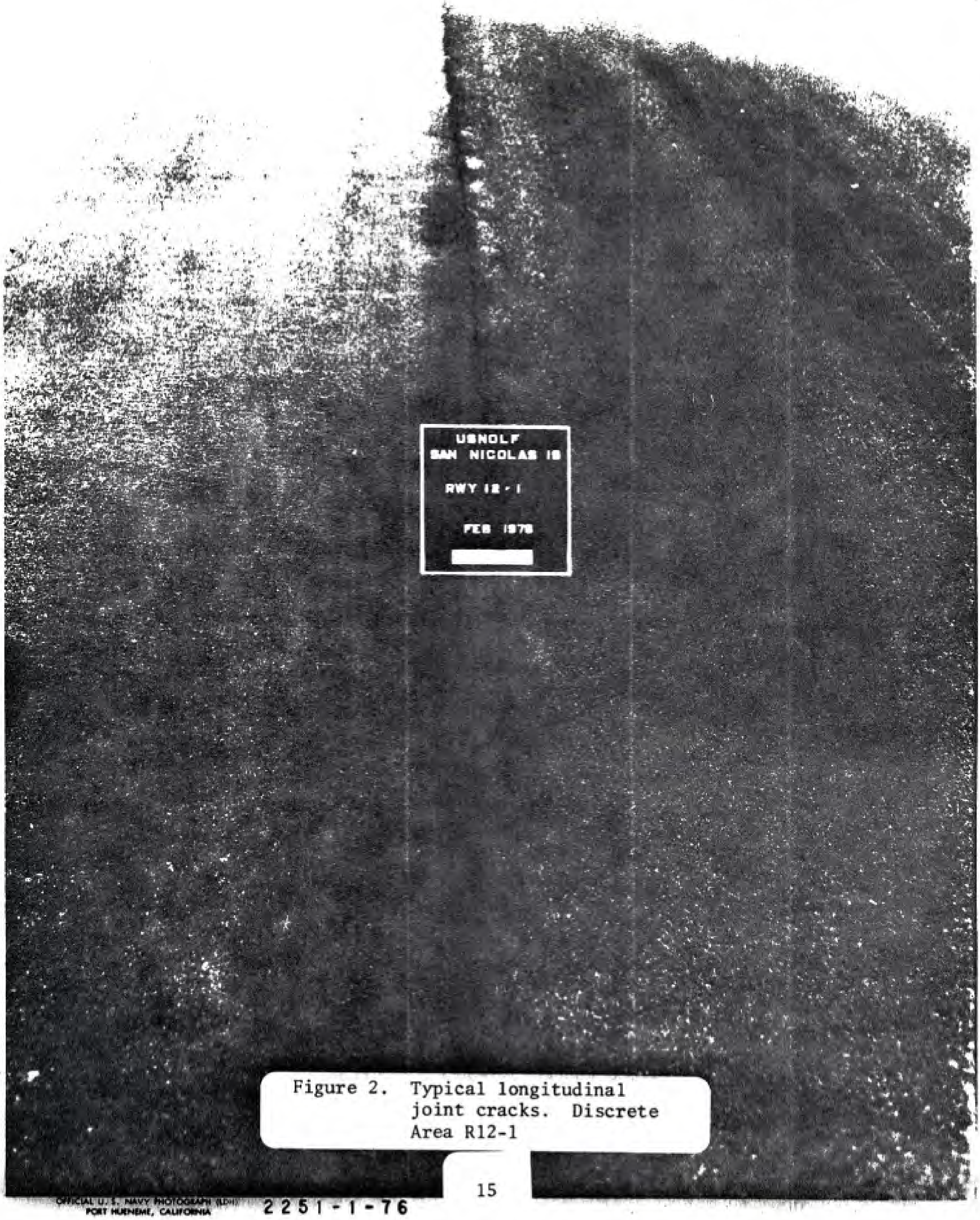
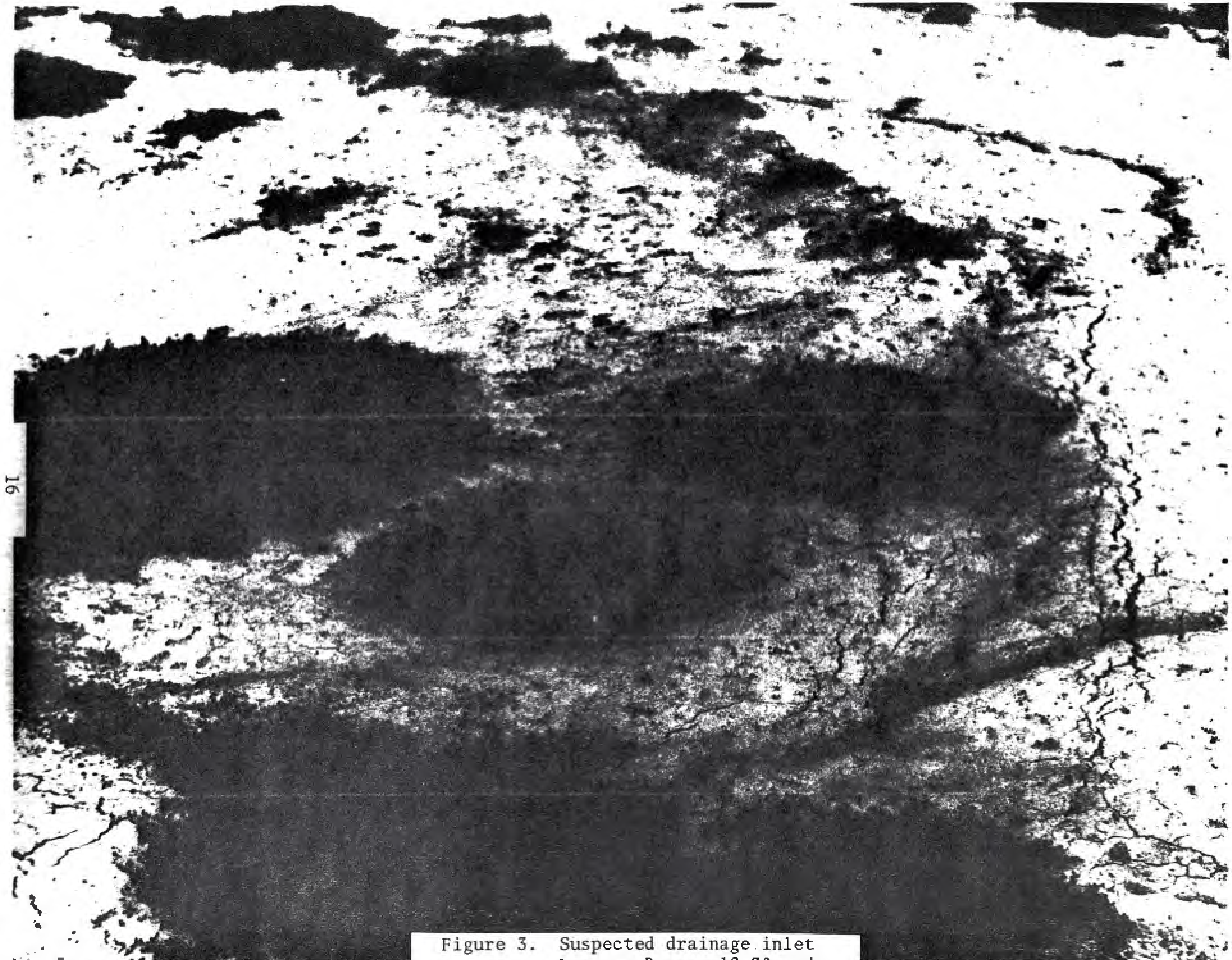


Figure 2. Typical longitudinal joint cracks. Discrete Area R12-1



OFFICIAL U. S. NAVY PHOTOGRAPH (LDH)
PORT HUENEME, CALIFORNIA

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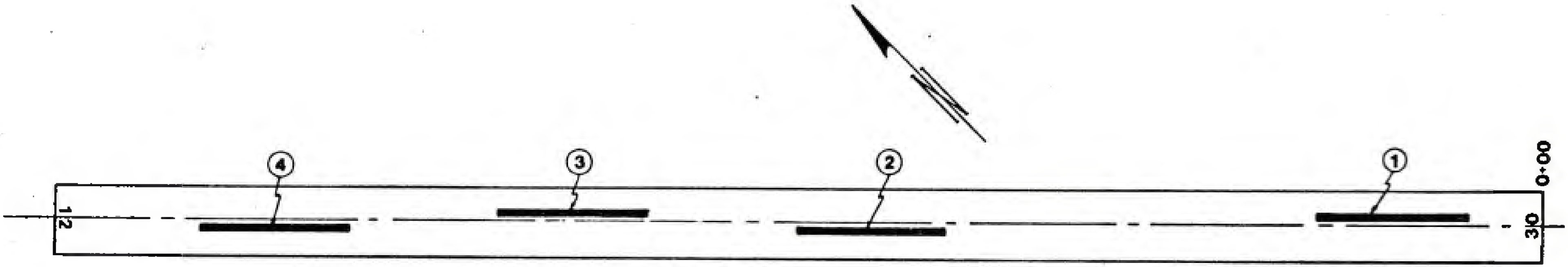
Figure 3. Suspected drainage inlet between Runway 12-30 and Taxiway 12-30



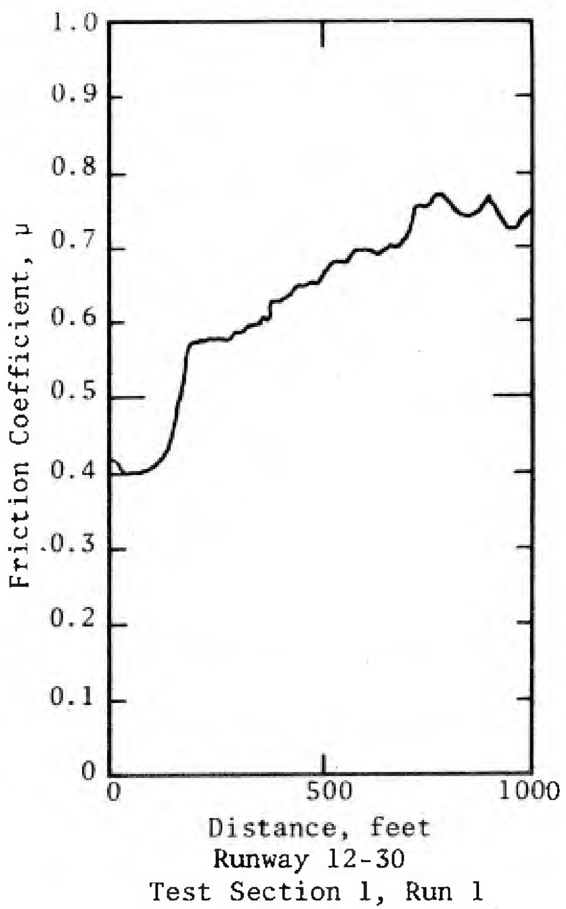
NOTE: Only runway shown for clarity

No scale

Runway and Test Location		Station	Offset from Center Line
Runway 12-30	1	5+00 to 15+00	5' right
	2	40+00 to 50+00	5' left
	3	60+00 to 70+00	5' right
	4	80+00 to 90+00	5' left

FRICTION TEST LOCATIONS
NOLF SAN NICOLAS ISLAND, CALIF.

FIGURE 4



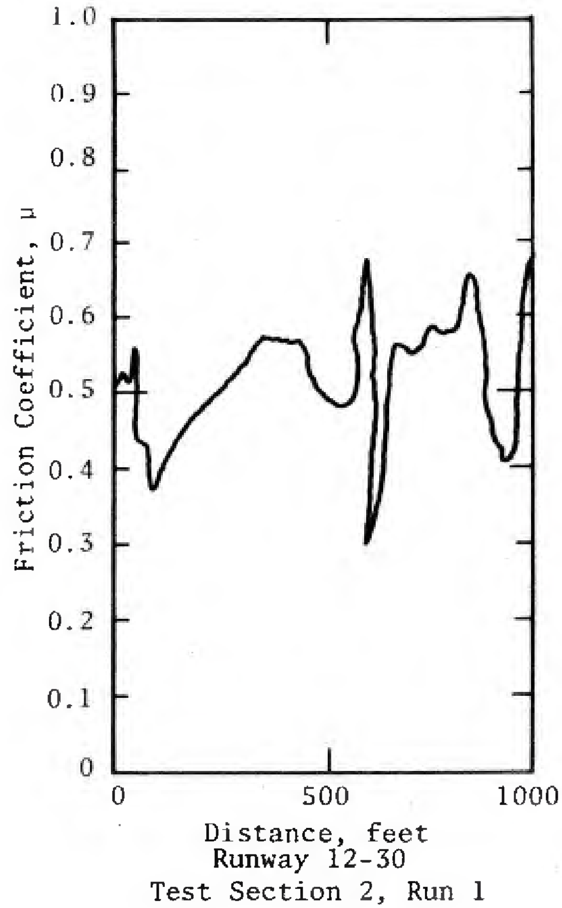


Figure 5. Friction coefficients versus distance, NOLF, San Nicolas Island, California

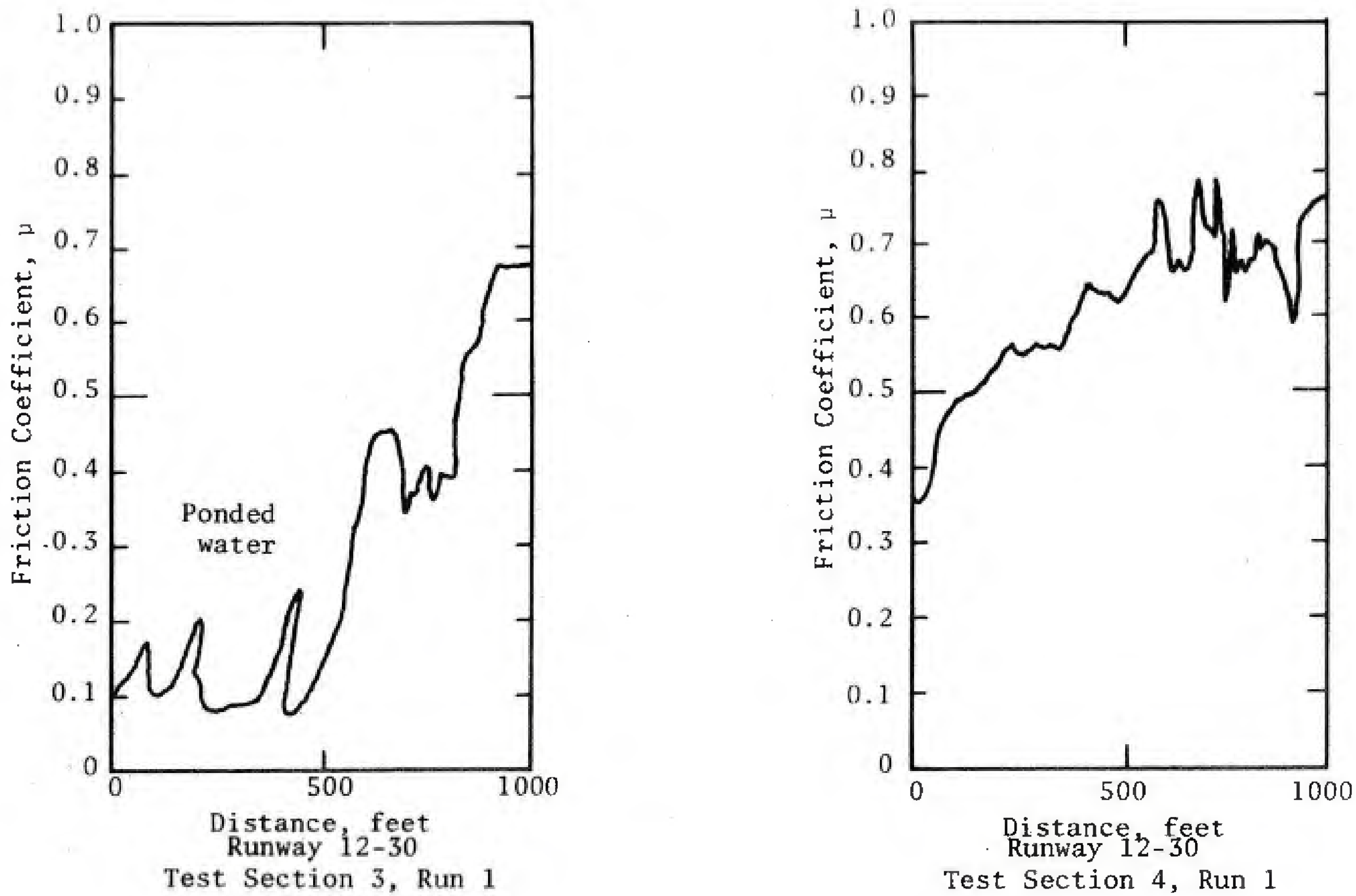
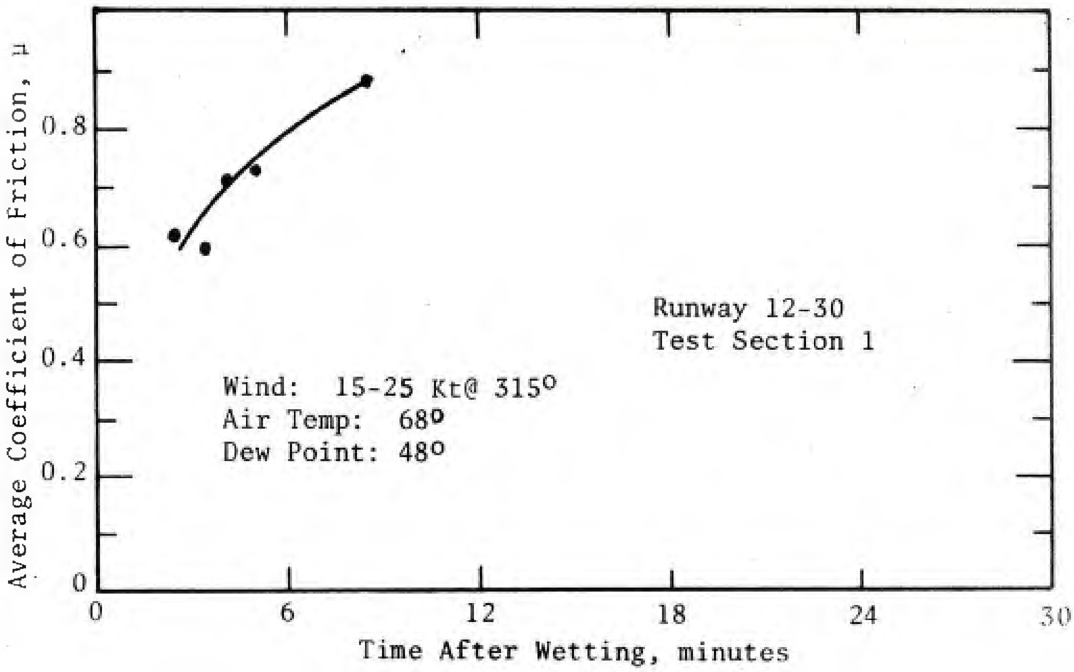


Figure 6. Friction coefficients versus distance,
NOLF San Nicolas Island, California



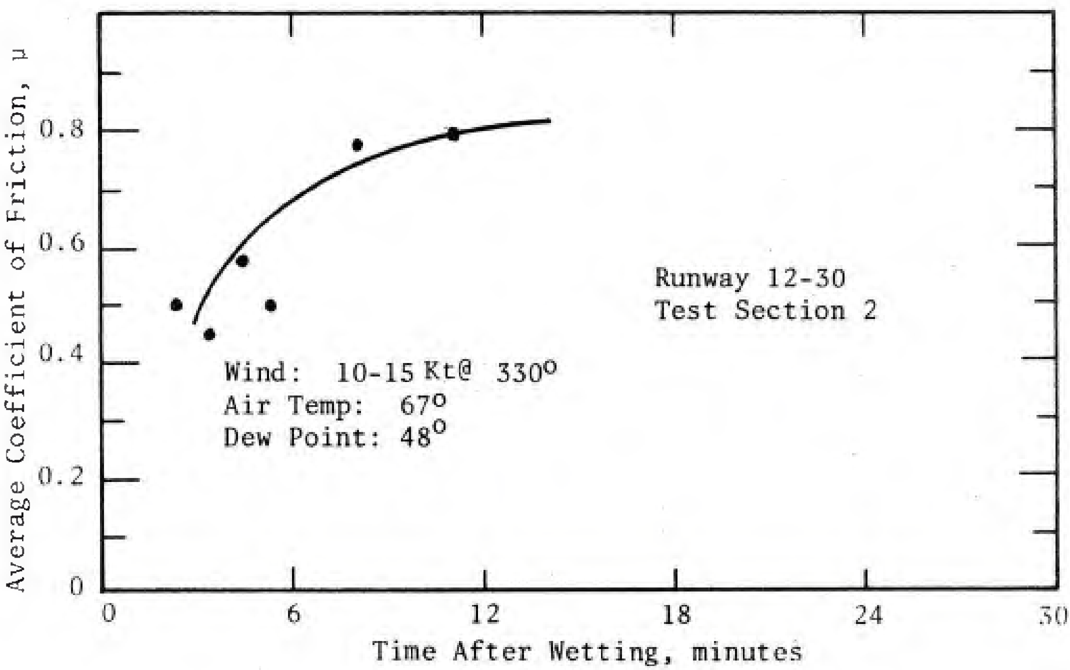


Figure 7. Average Friction Coefficient versus Time, NOLF San Nicolas Island, California

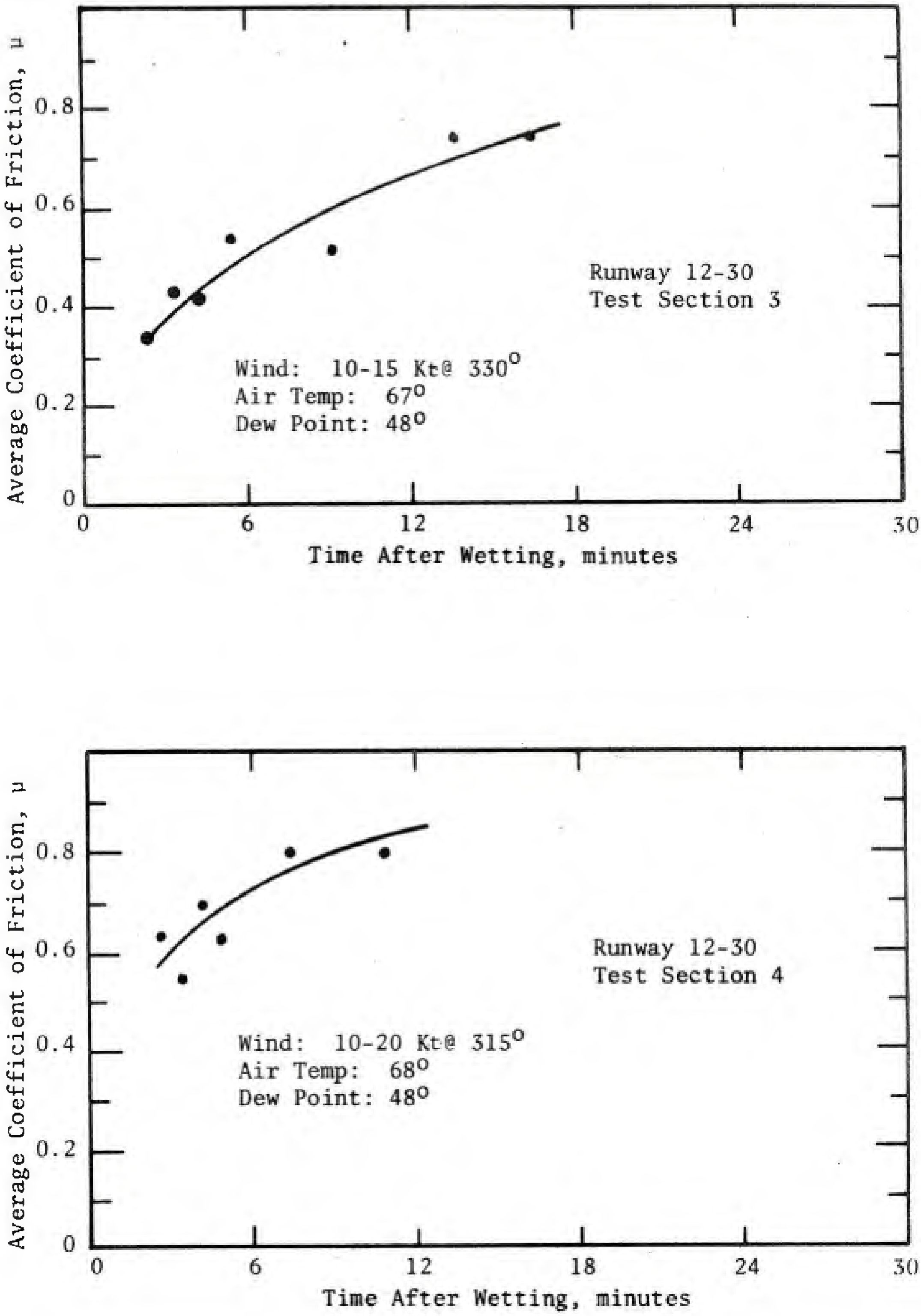
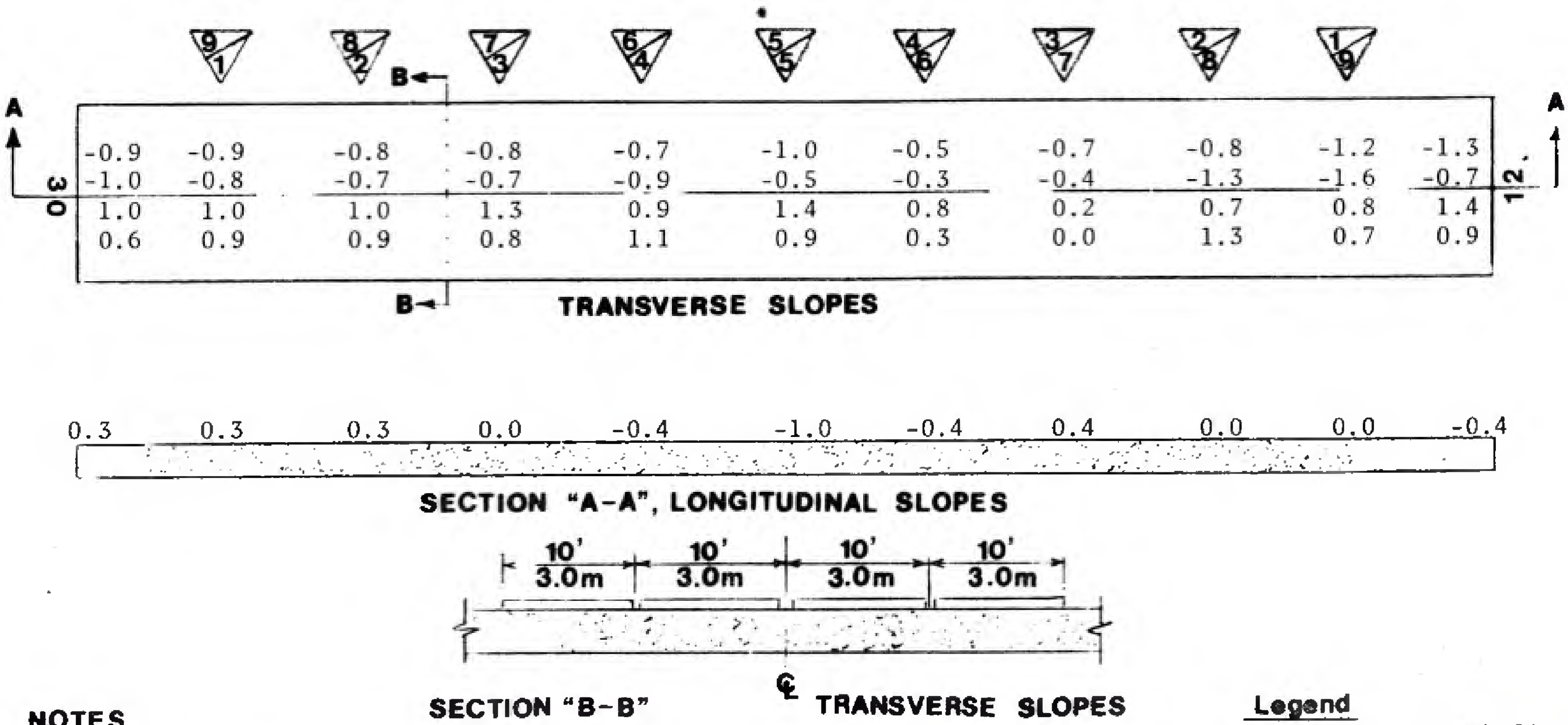


Figure 8. Average Friction Coefficient versus Time, NOLF San Nicolas Island, California

RUNWAY SLOPE MEASUREMENTS

USNOLF San Nicolas, Island, California



NOTES

1. All measurements are percent slope.
2. Positive transverse slopes indicate water drains to the runway edge without crossing the centerline, while negative transverse slopes indicate drainage across the centerline.
3. Positive longitudinal slopes indicate rising grades in the direction of increasing runway stationing, while falling grades are negative.
4. Runway stationing begins at **30** end.

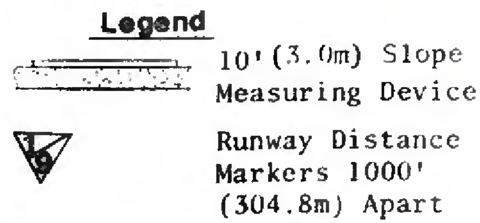


Figure 9

ASPHALTIC CONCRETE DISCRETE AREA DEFECT SUMMARY

Airfield USNOLF San Nicolas Island Facility Runway 12-30

Discrete Area R12-1 Area of Discrete Area (a) 400,000 ft^2

No. of Sample Areas (b) 15 Ratio: (a/2500b) 24.0

Defect Type	Length or Area of Sampled Defects	Total Length or Area of All Defects: (c) x Ratio	Defect Density (per 10 sq. ft.) 10 d/a	Defect Severity Weight	Weighted Defect Density: (e) x (f)
	(c)	(d)	(e)	(f)	(g)
T.C., L.C. or LCJ*	165 ft.	3960 ft.	0.044	3.0	0.132
Reflection Crack					
Faulting					
Patching		*** 2700 ft^2	0.030	3.5	0.105
Settlement or Depression					
Pattern Cracking					
Rutting					
Raveling					
Erosion—Jet Blast					
Oil Spillage					
Broken-up Area					
				Total	0.24A **

Remarks on Pavement Condition

The cracks were primarily longitudinal construction joints and were opened to a maximum width of ¼ inch (see Figure 2). The slurry seal placed in 1964 was completely eroded exposing the underlying pavement surface in a few places.

* Transverse crack, longitudinal crack or longitudinal construction joint crack.

** Letter suffix "A" indicates asphaltic pavement.

*** Singular defect

PORTLAND CEMENT CONCRETE DISCRETE AREA DEFECT SUMMARY

Airfield USNOLF San Nicolas Island Facility Taxiway 12-30

Discrete Area T12-2 Total Slabs in Discrete Area (a) 424

No. of Slabs Sampled (b) 106 Ratio a/b = 4.0

Defect Type	No. of Sample Slabs w/Defect	Total Slabs w/Defect: c x a/b	Defect Density (per slab) d/a	Defect Severity Weight	Weighted Defect Density e x f
	(c)	(d)	(e)	(f)	(g)
Faulting					
Corner Break					
L.C. or T.C.*					
I.C.**					
Depression					
Spalling	1	4	0.002	7.5	0.017
Scaling					
Shattered Slab					
Joint Seal					
Pumping					
"D-line" cracking					
				Total	0.017 C ***

Remarks on Pavement Condition

The spalls noted were small, less than 2 inches wide by 4 inches long.

* Longitudinal crack or Transverse crack
** Intersecting crack
*** Letter suffix "C" represents PCC pavement

Appendix A

CONSTRUCTION HISTORY

Appendix A

CONSTRUCTION HISTORY FOR USNOLF San Nicolas Island, California

Item No.	Section From Surface to Subgrade	Date Constructed	Date Strengthened or Sealed
1	Portions of Runway 12-30, Taxiways A,		
	B, and C		
	Reclamite seal Slurry Seal		1971 1964
	1-1/2" Asphaltic concrete overlay		1961
	1" Minimum Asphaltic concrete		
	leveling course		1961
	2" Asphaltic concrete		1951
	6" Asphalt stabilized sandstone	1942	
	11" Compacted sandstone sub-base	1942	
	9" Compacted native material	1942	
2	Portion of Taxiway 12-30		
	Reclamite seal Slurry seal		1971 1964
	1-1/2" Asphaltic concrete overlay 2" Asphaltic concrete		1961 1956
	6" Asphalt stabilized sandstone	1942	
	11" Compacted sandstone sub-base	1942	
	9" Compacted native material	1942	
3	Portions of Runway 12-30, Taxiway 12-30,		
	and Taxiway D		
	Reclamite seal Slurry Seal		1971 1964
	1-1/2" Asphaltic concrete overlay		1961

Appendix A

CONSTRUCTION HISTORY FOR USNOLF San Nicolas Island, California

Item No.	Section From Surface to Subgrade	Date Constructed	Date Strengthened or Sealed
3	Con't		
	1" Minimum asphaltic concrete		
	leveling course		1961
	2" Asphaltic concrete	1951	
	6" Asphalt stabilized sandstone	1951	
	11" Compacted select sandstone sub-base	1951	
	9" Compacted native material	1951	
4	Portions of Runway 12-30, Taxiway 12-30,		
	Taxiways A, B, C, and D		
	Reclamite seal Slurry Seal		1971 1964
	3" Asphaltic concrete	1961	
	10" Asphalt stabilized sandstone	1961	
	12" Compacted sandstone sub-base	1961	
	12" Compacted native material	1961	
5	Portions of Runway 12-30 and		
	Taxiway 12-30		
	Spalls repaired and joints sealed with Superseal 777		1975
	11" Portland cement concrete, reinforced 12" Compacted sandstone sub-base	1961 1961	
	12" Compacted native material	1961	

Appendix A

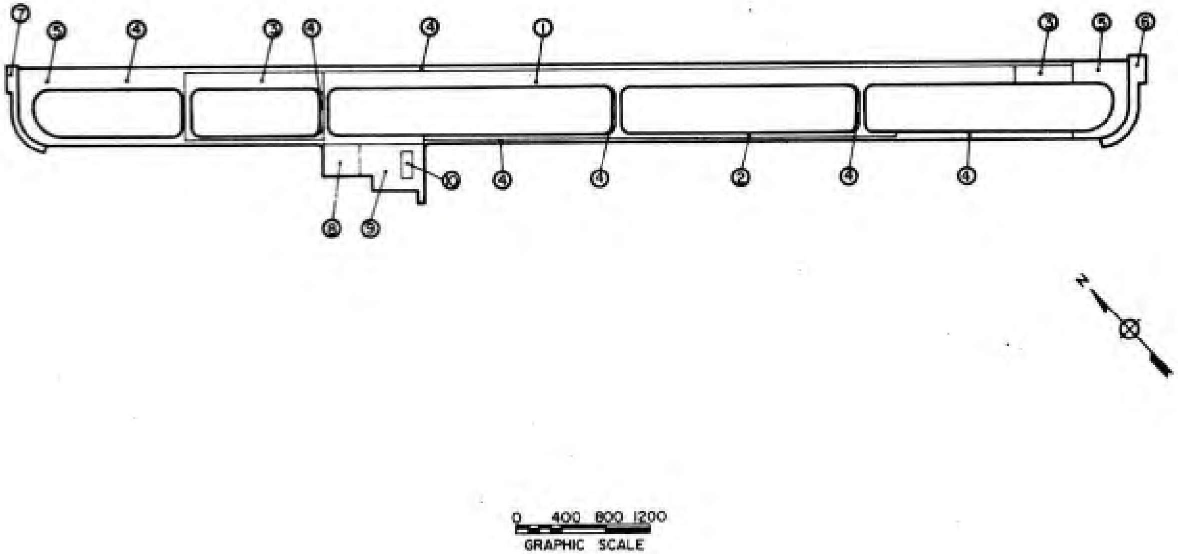
CONSTRUCTION HISTORY FOR USNOLF San Nicolas Island, California

Item No.	Section From Surface to Subgrade	Date Constructed	Date Strengthened or Sealed
6	Blast Pad, South end of Runway 12-30		
	and Taxiway 12-30		
	4" Portland cement concrete, reinforced	1965	
7	Blast Pad, North end of Runway 12-30		
	and Taxiway 12-30		
	Bituminous Seal Coat	1961	
	6" Soil cement	1961	
8	Portion of Parking Apron 1		
	1-1/2" Asphaltic concrete overlay		1961
	1" Minimum asphaltic concrete		
	leveling course		1961
	2" Asphaltic concrete		1951
	6" Asphalt stabilized sandstone	1942	
	11" Compacted sandstone sub-base	1942	
	9" Compacted native material	1942	
9	Portion of Parking Apron 1		
	Slurry Seal		1964
	1-1/2" Asphaltic concrete overlay		1961
	1" Minimum asphaltic concrete		
	leveling course		1961

Appendix A

CONSTRUCTION HISTORY FOR USNOLF San Nicolas Island, California

Item No.	Section From Surface to Subgrade	Date Constructed	Date Strengthened or Sealed
9	Con't		
	2" Asphaltic concrete		1951
	6" Asphalt stabilized sandstone	1942	
	11" Compacted sandstone sub-base	1942	
	9" Compacted native material	1942	
10	Portion of Parking Apron 1		
	8" Portland cement concrete	1965	
	6" Imported base 40 CBR	1965	
	6" Compacted native material	1965	



USNOLF SAN NICOLAS ISLAND
PAVEMENT CONDITION SURVEY
CONSTRUCTION HISTORY

U. S. NAVAL CIVIL ENGINEERING LABORATORY

APPENDIX A, FIGURE A-I

APPENDIX B

CONDITION SURVEY PROCEDURES

Appendix B

CONDITION SURVEY PROCEDURES

Step 1. Preliminary Survey

In the preliminary survey the evaluators make a general and personal inspection of all airfield pavement areas, during which they note the type and distribution of defects in each facility (runway, taxiway, etc.). In addition, a previously-prepared construction history is consulted and areas of different construction and different pavement type (AC or PCC) within a facility are noted. As a result of these efforts, each pavement facility is then divided into "discrete areas" of reasonably similar failure modes for performance of the subsequent sampling and tally or measurement of defects. Thus, if the type and/or number of defects found in one portion of a facility are distinctly different from those found in another portion of that facility, discrete areas are selected on this basis. If, however, the pavement facility contains few defects or if the defects found are similar in type and distribution throughout the facility, each facility is individually divided for survey according to the construction history. Under either criterion, a discrete area may vary, for example, from a 500 foot length of runway or taxiway to the entire length of the facility. All discrete areas are numbered with a system that relates the discrete area to the runway, taxiway, etc., of which it is a part. For example, discrete areas comprising Runway 11-29 are designated R 11-1 and R 11-2, etc.; discrete areas for Taxiway 2 are T 2-1 and T 2-2, etc.

A special survey of singular occurrences of serious defects is made during the preliminary survey. This is necessary because the statistical sampling techniques utilized in the subsequent survey are effective in spotting defects only when such defects are numerous and/or relatively well distributed. This abbreviated special survey provides information on those infrequent defects, if any, which may present a problem to safe aircraft operation.

Step 2. Statistical Sampling and Defect Survey

After discrete areas are selected, a number of small "sample areas" are chosen within each discrete area. The total number of sample areas is determined by statistical theory as a function of the relative size of the discrete area. Actual locations of the sample areas are selected at random from the discrete area.

Sample areas in PCC pavements basically consist of individual slabs, usually 12½ x 15 feet in size. For the convenience of the evaluators, either a single slab or a number of adjacent slabs can be considered as a sample area. Both types of sampling area are shown schematically in Figure B-1. Note from Figure B-1 that individual sample slabs and/or sample strips are selected within the center 100 feet (laterally) of runways and within the center 50 feet (laterally) of taxiways by a random selection process. For parking aprons, mats, etc., similar sample areas are selected at random over the entire pavement area.

For AC pavements, sample areas are fifty-foot-square areas located as shown in Figure B-2. For parking aprons, mats, etc.(not shown in Figure B-2) sample areas are fifty-feet square, as for other traffic areas, and randomly located over the entire pavement area.

All defects or defected slabs in each of the selected sample areas are noted on appropriate data sheets. For PCC pavement slabs or sample strips, either single or multiple occurrences of a given defect type within the slab qualify the slab as a defected slab. For example, one or more spalls qualifies a slab as a spalled slab. A crack in the same slab requires that it be counted again, this time as a cracked slab. No measurement of length, area, etc. is recorded for PCC pavement defects. When a sample slab strip is chosen for test, the above mentioned tally method (slab by slab) is still utilized.

The defects found in AC sample areas are measured and tallied, rather than merely tallied as are those for PCC pavements. Depending on the type of defect, the total length in feet (for cracks, etc.) or total area in square feet (for pattern cracking, raveling, etc.) is recorded.

The above survey of defects found in sample areas (in each discrete area) are shown in column (c) of the Discrete Area Defect Summary sheets, Figures B-3 and B-4. Separate summary sheets are provided for portland cement concrete (PCC) and asphaltic concrete (AC) pavements. Total defect counts for the entire discrete area are calculated by a linear extrapolation of the defect data in column (c), and are shown in column (d) of the Discrete Area Defect Summary sheets. To remove the influence of the size of the discrete area on the total defect count, the count is divided by either the number of slabs in the discrete area (for PCC pavements) or by the area (in 10-square-foot increments) of the discrete area (for AC pavements). This gives a defect density (per slab or per 10 square feet) which is listed in column (e).

Step 3. Defect Severity Weighting System

A weighting system, providing a numerical weight for each type defect in proportion to the relative severity of that defect, is applied in the following manner to each of the defect counts in the discrete area;

$$\text{given defect density} \times \begin{matrix}\text{weight for that}\\ \text{type defect}\end{matrix} = \begin{matrix}\text{weighted defect}\\ \text{density}\end{matrix}$$

This is accomplished in columns (f) and (g) of the Discrete Area Defect Summary sheets. Next, a total weighted defect density is obtained for each discrete area by summing column (g) of these sheets. Note that a letter suffix is added to each total weighted defect density for the purpose of further distinguishing between asphaltic concrete defect densities (suffix "A") and portland cement concrete defect densities (suffix "C").

The defect weighting guide developed by NCEL assigns greater weights to defects that (1) presently affect the safe operation of aircraft or the cost of aircraft operation; (2) will lead to increased airfield pavement maintenance costs; or (3) will result in significant deterioration of load-carrying capacity of the pavements. The resultant numerical weights are further modified to reflect variations in pavement environment from station to station. For example, higher (more severe) weights are assigned to defects which are affected by factors such as freezing weather, heavy rainfall, or blow sand for surveys of airfields located in areas where these undesirable environmental effects occur. Thus, it can be seen that the higher the numerical weighted defect density, the poorer the condition of the surveyed pavement.

Remarks concerning the general pavement condition and the defects identified are given in narrative form on each Discrete Area Summary sheet. In addition, photographs of typical pavement conditions noted during the survey are used to further illustrate typical pavement defects.

Step 4. Facility Summary-- Weighted Defect Densities

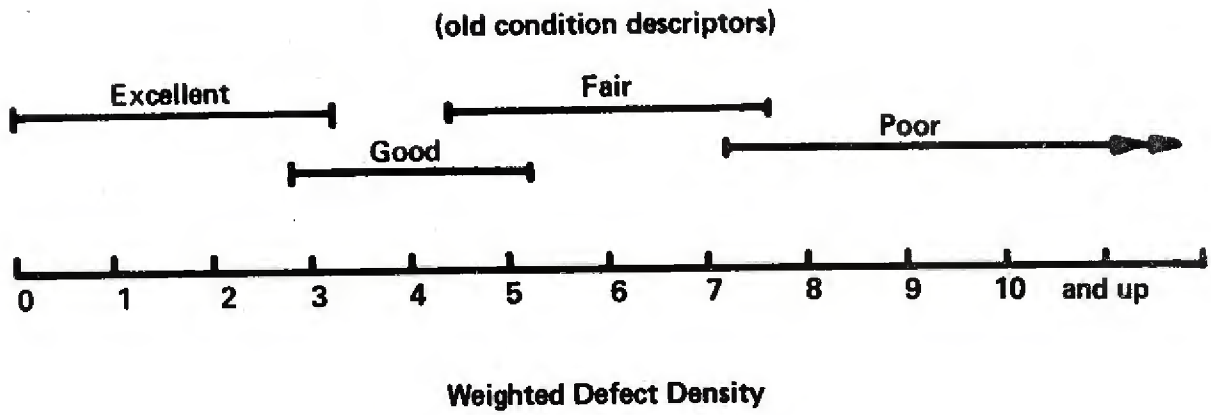
A final step in providing a numerical condition rating for each facility (runway, taxiway, etc.) is accomplished in the Facility Defect Summary sheets, Figures B-5 and B-6. Again note that separate sheets have been provided for AC and PCC pavements. In these sheets the individual weighted defect densities for all discrete areas comprising the entire AC or PCC portion of a facility (runway, taxiway, etc.) are summarized in column (a). When an AC or PCC facility (or portion) has been divided into more than one discrete area for the condition survey, the proportional contribution of each discrete area to the entire AC or PCC facility area is determined in column (b). In column (c) these proportions are applied to the individual discrete area weighted defect densities listed in column (a) and added to obtain an overall average weighted defect density for the entire AC or PCC portion of the facility (marked "total" in column (c)). When an entire AC or PCC facility (or portion) has been designated a single discrete area (as often occurs), the proportionality factor in column (b) is obviously 1.00 and the discrete area weighted defect density from column (a) becomes the average weighted defect density for the entire facility (or portion) in column (c).

GENERAL COMMENTS ON CONDITION SURVEY PROGRAM

The weighted defect densities, listed in column (a) of the Facility Defect Summary for individual discrete pavement areas and in column (c) as averaged weighted defect densities for entire AC or PCC runways, taxiways, etc. (or portions thereof) represent, numerically, the surface condition of the airfield pavements at the station. As previously stated, the larger defect density numbers indicated basically a greater number and/or severity of defects per unit area of pavement, i.e., a poorer pavement. Thus, they represent the final product of the pavement condition survey. It should be noted specifically, however, that AC and PCC pavement defect densities, although often numerically similar, are obtained by two different condition survey techniques and, as such, are not numerically compatible and must not be combined. (It is largely because of this fact that the letter suffixes "A" and "C" have been affixed to defect densities for AC and PCC pavements respectively.) As an example, consider the common case of an AC runway with PCC ends. The condition survey system presented herein provides indivdual discrete are weighted defect densities for discrete areas selected on both AC and PCC pavements, but provides a separate average weighted defect density for the entire AC portion and a separate average weighted defect density for the combined PCC end pavements. It is not possible to combine these defect densities to obtain an average AC/PCC defect density for the entire runway. Thus the defect densities for AC and PCC are reported separately, given different letter suffixes, and should include the letter suffix when reference is made to them.

Individual numerical defect densities, however accurately they indicate pavement condition, may mean little to the reader of an individual airfield condition survey report, for he has no basis upon which to judge the relative severity of pavement condition associated with the numbers obtained for his pavements. The primary value of a numerical condition survey program will be the accumulation of uniformly-obtained, comparative condition data for many airfields which can best be correlated, studied, and used in the decision-making processes at headquarters levels.

For the benefit of the individual reader, however, an effort was made during the first year of pavement condition surveys (FY-70) to relate the numerical condition (defect densities) to the basic subjective condition descriptors (excellent, good, fair, poor, etc.) used in all previous Navy pavement evaluation procedures. Although the subjective condition-descriptor approach is poorly regarded as a means of comparing pavement condition from one airfield to another, the following diagram may serve temporarily as a rudimentary bridge between the old subjective system and the new (numerical) condition approach:



The system of numerical defect densities was developed to aid in determining the suitability of airfield pavement surfaces for satisfying aircraft operational requirements and to establish an unbiased, uniform basis for initiating maintenance and repair efforts. As such, defect densities are simply visually-determined indicators of the condition of the pavement and do not represent true "condition ratings" in that they do not include factors relating to pavement strength, traffic usage, etc. It is possible that additional measurements or modifications may be considered necessary or desirable in future condition survey programs.

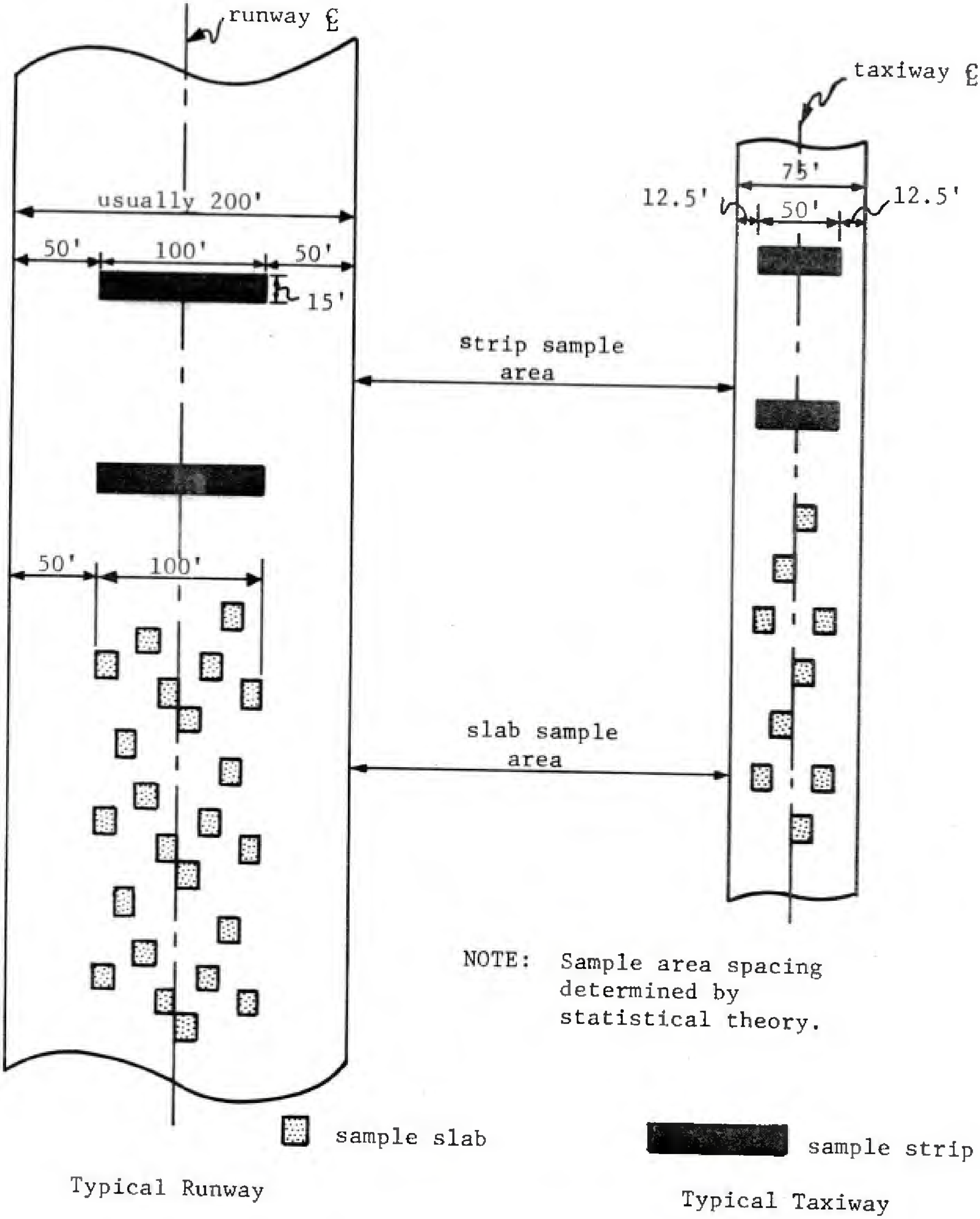


Figure B-1. Portland cement concrete sample areas.

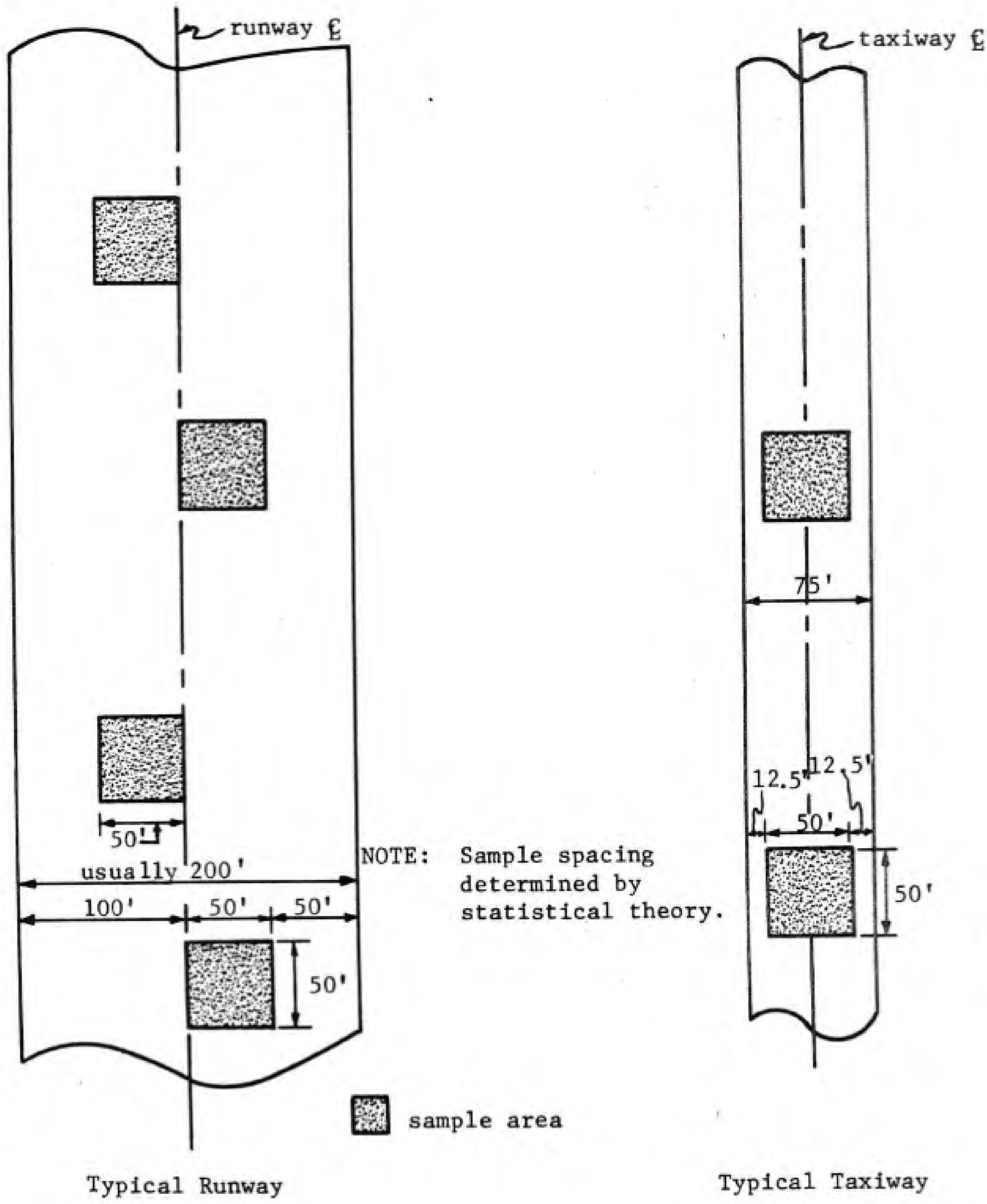


Figure B-2. Asphaltic concrete sample areas.

ASPHALTIC CONCRETE DISCRETE AREA DEFECT SUMMARY

Airfield E X A M P L E Facility Taxiway 2

Discrete Area T2-1 Area of Discrete Area (a) 97,700 ft^2

No. of Sample Areas (b) 10 Ratio: (a/2500b) 3.9

Defect Type	Length or Area of Sampled Defects	Total Length or Area of All Defects: (c) x Ratio	Defect Density (per 10 sq. ft.) 10 d/a	Defect Severity Weight	Weighted Defect Density: (e) x (f)
	(c)	(d)	(e)	(f)	(g)
T.C., L.C. or LCJ*	80 ft	312 ft	0.0319	2.5	0.0798
Reflection Crack					
Faulting					
Patching					
Settlement or Depression	530 ft^2	2,067 ft^2	0.2116	9.0	1.9041
Pattern Cracking	126 ft^2	491.4 ft^2	0.0503	2.5	0.1257
Rutting					
Raveling					
Erosion—Jet Blast					
Oil Spillage					
Broken-up Area					
				Total	2.11 A**

Remarks on Pavement Condition

The depressions were generally 1/2" deep. Pattern cracking formed 6" to 12" polygons and was associated with the depressions. Longitudinal cracks were unsealed and 1/8" wide. (See Figure 5.)

* Transverse crack, longitudinal crack, and longitudinal construction joint

** Letter suffix "A" indicates asphaltic concrete pavement

Figure B-3. Typical Asphaltic Concrete Discrete Area Defect Summary

PORTLAND CEMENT CONCRETE DISCRETE AREA DEFECT SUMMARY

Airfield E X A M P L E Facility Taxiway 2

Discrete Area T2-2 Total Slabs in Discrete Area (a) 1,542

No. of Slabs Sampled (b) 193 Ratio a/b = 8.0

Defect Type	No. of Sample Slabs w/Defect	Total Slabs w/Defect: c x a/b	Defect Density (per slab) d/a	Defect Severity Weight	Weighted Defect Density e x f
	(c)	(d)	(e)	(f)	(g)
Faulting					
Corner Break	1	8	0.0052	2.5	0.013
L.C. or T.C. *	19	152	0.0985	1.0	0.098
I.C. **	1	8	0.0052	2.5	0.013
Depression		2***	0.0013	9.0	0.012
Spalling	59	472	0.3060	7.5	2.295
Scaling					
Disintegrated Slab					
Joint Seal	10	80	0.0518	2.5	0.130
Pumping					
				Total	2.57 C****

Remarks on Pavement Condition

Spalls were generally 1" wide by 3" long with some spalls up to 4" wide and 12" long. The longitudinal cracks found were mostly sealed. The depressions noted as singular defects consisted of two depressed and cracked slabs. The depression was approximately 1/2" deep. An attempt had been made to repair these slabs with portland cement concrete. Joint seal was missing in strips 4" to 12" long. (See Figures 25 and 26.)

* Longitudinal crack or transverse crack
** Intersecting crack
*** Counted as singular defects during the preliminary survey
**** Letter suffix "C" indicates portland runway concrete pavement

Figure B-4. Typical Portland Cement Concrete Discrete Area Defect Summary

ASPHALTIC CONCRETE FACILITY DEFECT SUMMARY Airfield EXAMPLE Date Surveyed			
Facility (or portion)	Weighted Defect Density Total	Ratio: Discrete Area / Total Facility Area*	Average Weighted Defect Density (a) x (b)
	(a)**	(b)	(c)**
Taxiway 2			
T2-1	2.11 A	1.00	2.11 A
Taxiway 10			
T10-2	0.004 A	1.00	0.004 A
Towway 1			
TOW-1	3.77 A	1.00	3.77 A
Parking Apron 2			
PA2-1	7.29 A	1.00	7.29 A
Parking Apron 6			
PA6-1	7.44 A	1.00	7.44 A
Parking Apron 7			
PA7-1	4.97 A	0.79	3.93
PA7-2	23.18 A	0.21	4.87
			8.80 A (Total)
Parking Apron 8			
PA8-1	2.76 A	1.00	2.76 A
Central Mat			
CM-1	2.89 A	1.00	2.89 A

* If facility entirely constructed of AC, indicates total facility area. If facility only partly constructed of AC, indicates total area of AC portion of facility.

** Letter suffix "A" on weighted defect densities indicates asphaltic concrete pavements.

Figure B-5. Typical Asphaltic Concrete Facility Defect Summary

PORTLAND CEMENT CONCRETE FACILITY DEFECT SUMMARY

Airfield E X A M P L E

Date Surveyed

Facility (or portion)	Weighted Defect Density Total	Ratio: Discrete Area / Total Facility Area*	Average Weighted Defect Density (a) x (b)
	(a)**	(b)	(c)**
Runway 11-29			
R11-1	0.80 C	0.25	0.02
R11-2	4.43 C	0.75	3.33
			3.35 C (Total)
Runway 18-36			
R18-1	1.25 C	0.68	0.85
R18-2	0.76 C	0.32	0.28
			1.13 C (Total)
Taxiway 1			
T1-1	2.82 C	0.12	0.34
T1-2	0.98 C	0.88	0.86
			1.20 C (Total)
Taxiway 2			
T2-2	2.57 C	1.00	2.57 C
Taxiway 3			
T3-1	1.82 C	1.00	1.82 C
Taxiway 4			
T4-1	3.02 C	1.00	3.02 C
Taxiway 5			
T5-1	0.98 C	1.00	0.98 C
Taxiway 6 and Taxiway 7			
T6-1 and T7-1	0.06 C	1.00	0.06 C

* If facility entirely constructed of PCC, indicates total facility area. If facility only partly constructed of PCC, indicates total area of PCC portion of facility.

** Letter suffix "C" on weighted defect densities indicates Portland cement concrete pavements.

Figure B-6. Typical Portland Cement Concrete Facility Defect Summary

APPENDIX C

MU-METER TEST RESULTS
USNOLF SAN NICOLAS ISLAND, CA

APPENDIX C
MU-METER TEST RESULTS
USNOLF SAN NICOLAS ISLAND, CA

Test Location Run #	Runway Heading	Average Time After Wetting Min.	Average Coefficient of Friction (Mu)	Maximum Coefficient of Friction (Mu)	Minimum Coefficient of Friction (Mu)
Runway 12-30					
Test Section 1					
1	30	2.56	0.62	0.78	0.40
2	12	3.32	0.60	0.80	0.41
3	30	4.07	0.72	0.82	0.54
4	12	4.96	0.74	0.89	0.56
5	30	8.47	0.88	0.91	0.78
Test Section 2					
1	30	2.29	0.50	0.70	0.30
2	12	3.31	0.45	0.63	0.11
3	30	4.36	0.58	0.74	0.43
4	12	5.26	0.50	0.69	0.29
5	30	8.01	0.78	0.84	0.56
6	12	10.99	0.80	0.87	0.62
Test Section 3					
1	30	2.42	0.33	0.68	0.08
2	12	3.17	0.43	0.78	0.21
3	30	4.13	0.41	0.83	0.12
4	12	5.20	0.54	0.81	0.39
5	30	9.25	0.51	0.86	0.14
6	12	13.63	0.74	0.89	0.44
7	30	16.67	0.74	0.91	0.24
Test Section 4					
1	30	2.50	0.64	0.80	0.36
2	12	3.27	0.54	0.80	0.36
3	30	4.02	0.70	0.87	0.47
4	12	4.82	0.63	0.84	0.43
5	30	7.20	0.80	0.90	0.66
6	12	10.70	0.80	0.88	0.64